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Analysis of Capacity and Service Level of Kawi Atas Road Segment Using PKJI Method 2023

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Abstract. The increase in community activity in urban areas has led to a rise in traffic volume on main roads, including Kawi Atas Street in Malang City, which serves as an important corridor to educational, commercial, and public facility areas. This situation has resulted in increased traffic pressure, affecting road performance. Furthermore, the existence of side obstacles such as on-street parking, pedestrian activities, and vehicles entering and exiting shop areas also reduces road capacity and service quality. This study aims to analyze the capacity, degree of saturation, and level of service of Jalan Kawi Atas based on the 2023 Indonesian Road Capacity Guidelines (PKJI). The research method was carried out through primary surveys in the form of traffic volume observation, side obstacle assessment, and road geometric condition analysis, supported by secondary data related to area characteristics. The data obtained were subsequently processed to calculate road capacity, free-flow speed, degree of saturation, and level of service. The analysis results indicate that high traffic volumes and roadside obstructions significantly contribute to the decrease in road performance. Therefore, measures are required to enhance traffic smoothness, comfort, and safety in the area.

Introduction

Background. The growth of the population in urban areas increases the demand for transportation facilities and infrastructure, particularly road infrastructure, which functions as a key element in supporting community mobility [1]. The inability of the road network to accommodate increased traffic flows can lead to a decline in operational performance, marked by increased congestion, reduced travel speeds, longer travel times, and an overall decrease in service levels [2]. As the city of Malang develops as a center for education, trade, and social activities, the intensity of community mobility experiences a significant increase [3]. This growth in activity requires an urban traffic system capable of providing adequate capacity so that vehicle movements can occur safely, comfortably, and efficiently [4].

One of the key roads that plays an important role in supporting urban activities is Jalan Kawi Atas, which connects commercial areas, educational institutions, residential neighborhoods, and other public facilities. The high activity along this corridor causes traffic volumes to fluctuate throughout the day [5]. Besides the increase in vehicle flow, there are also various side obstacles such as street parking, pedestrian activities, vehicles stopping temporarily, and vehicles entering and exiting shop areas. This phenomenon aligns with study findings showing that side obstacles significantly contribute to reduced capacity and service levels of urban roads [6]. Poorly managed roadside

activities increase traffic conflicts and reduce the effective space for moving vehicles, directly impacting road performance [2].
This situation shows the need for an in-depth evaluation of Kawi Atas Street's ability to handle the current traffic flow. Analyzing capacity, level of saturation, and service level is an important step to fully understand the road's operational condition and serves as a basis for traffic management and transportation planning in the ever-growing Malang City area [7].

Research Objective. This study aims to analyze the operational performance of the Kawi Atas Road section based on road capacity indicators, degree of saturation (DS), and level of service (LOS) according to the Indonesian Road Capacity Guidelines (PKJI) 2023. The analysis is carried out by calculating traffic volume converted into passenger car units (PCU), evaluating the actual road capacity based on geometric conditions and side obstacles, as well as calculating DS and LOS values as road performance parameters. The goal is formulated to understand how well the road can serve the community's mobility needs and to identify significant factors in determining the performance of the urban road network. This study is also expected to provide a basis for relevant and practical traffic management policy recommendations in Malang City.

Road Capacity according to PKJI. According to the Indonesian Road Capacity Guidelines (PKJI) 2023, road capacity is defined as the maximum traffic volume that a road segment can still accommodate within a certain period under specified geometric, environmental, and operational conditions. Capacity calculations adjust to actual road conditions through correction factors such as lane width, directional separation, roadside obstacles, and city size, thereby producing capacity values that are representative of field conditions. In general, the capacity equation in PKJI 2023 is expressed as follows:

$$C = C_0 \times FC_{LJ} \times FC_{PA} \times FC_{HS} \times FC_{UK} \quad (1)$$

where:
C = Road capacity (PCU/hour)
C_0 = Base capacity under ideal conditions
FC_{LJ} = Capacity correction factor due to differences in lane width or traffic lanes
FC_{PA} = Traffic direction separation correction factor (PA)
FC_{HS} = Side obstruction correction factor
FC_{UK} = City size correction factor

Side Friction according to PKJI. Side friction or side resistance is one of the important factors included in the calculation of road capacity and performance according to PKJI 2023. Side friction encompasses all activities around the road edges that can affect vehicle movement on the roadway, such as pedestrians, on-street parking, stopped vehicles, slow-moving vehicles, as well as vehicles entering and exiting adjacent land [8]. PKJI 2023 establishes a methodology for measuring side friction based on the frequency of occurrences and the weight of each type of friction, which is then converted into an adjustment factor (FC_{HS}) value in the calculation of capacity and speed.

Table 1. Determination of Side Friction Frequency Type on Urban Roads (PKJI, 2023)

Main Side Friction Types	Weight
Pedestrians on the carriageway and crossing	0.5
Public transport and other vehicles stopping	1.0

Vehicles entering/exiting roadside properties or access points	0.7
Slow-moving vehicles (non-motorized vehicles)	0.4

Table 2. Side Friction Class Criteria for Urban Roads (PKJI, 2023)

Side Friction Class (SFC)	Total weighted frequency count (both sides of the road)	Special Characteristics
Very Low (VL)	<100	Residential area, frontage road available
Low (L)	100–299	Residential area, some public transport (city transit) available
Medium (M)	300–499	Industrial area, some shops along the roadside
High (H)	500–899	Commercial area, high roadside activity
Very High (VH)	≥900	Commercial area, roadside market activity present

Level of Service Based on Degree of Saturation (PKJI). The road Level of Service (LOS) is a qualitative measure used to describe traffic operational conditions, including the level of comfort and ease of vehicle movement on a road segment. According to Ofyar Z. Tamin [1], road level of service is classified into six categories, namely A through F, indicating traffic flow conditions ranging from very smooth to highly congested. In the Indonesian Road Capacity Manual (PKJI) 2023, the determination of road level of service is based on the degree of saturation (DS), which represents the ratio between actual traffic volume (q) and road capacity (C).

$$D_J = \frac{q}{c} \tag{2}$$

The DS value is used to classify road operational conditions into levels of service ranging from A to F, where LOS A indicates free-flow conditions with minimal disruption, while LOS F describes saturated and unstable flow conditions. The application of the PKJI 2023 method in various studies demonstrates that the LOS indicator is capable of providing a representative description of road segment performance, particularly in urban areas, and can serve as a basis for more effective traffic management planning and evaluation [9].

Table 3. Level of Service Categories (PKJI, 2023)

Level of Service	Degree of Saturation
A	< 0.35
B	< 0.54
C	< 0.77
D	< 0.93
E	< 1.0
F	> 1

Research Method

Research Method. This study employs a descriptive quantitative research approach. This method was selected to evaluate road operational performance through the collection of numerical field data, which is subsequently analyzed mathematically. The road segment performance analysis in this study is entirely based on the Indonesian Road Capacity Manual (PKJI) 2023 for urban roads. The primary

objective of this research is to determine the capacity value (C) and Level of Service (LOS) of Kawi Atas Street, Malang City. The evaluation is conducted by comparing the actual traffic flow load (Q) against the maximum road space capacity to accommodate vehicles. This analysis also considers the influence of road user behavior, including traffic violation factors (such as illegal parking or shoulder road activities), which are converted into the Side Friction Adjustment Factor.

Data Processing Method. The data processing stage is carried out based on collected field data, which is then analyzed using the Indonesian Road Capacity Manual (PKJI) 2023 method. The analysis process encompasses the calculation of traffic volume in passenger car units (pcu), determination of road capacity based on geometric conditions and side friction, as well as the calculation of the degree of saturation (DS). Subsequently, the DS value is used to determine the road Level of Service (LOS) as a road segment performance indicator. The analysis results are used to evaluate the existing road conditions in accommodating traffic activities, as well as to assess their conformity with the applicable road performance standards in Indonesia [1], [10].

Results And Discussion

Geometric Data.

Road Name : Kawi Atas
Road Status : Urban Road
Road Type : Undivided
Number of Lanes : 4 lanes
Number of Directions : 2 directions
Road Width : 12 meters
Lane Width : 3 meters
Shoulder Width : 0.5 meters (Direction A), 0.3 meters (Direction B)

The survey was conducted on February 20–21, 2026. The exact location is at Kawi Atas Street No. 46, Gading Kasri, Klojen District, Malang City, East Java 65116. The following presents the road geometric layout based on the field survey:

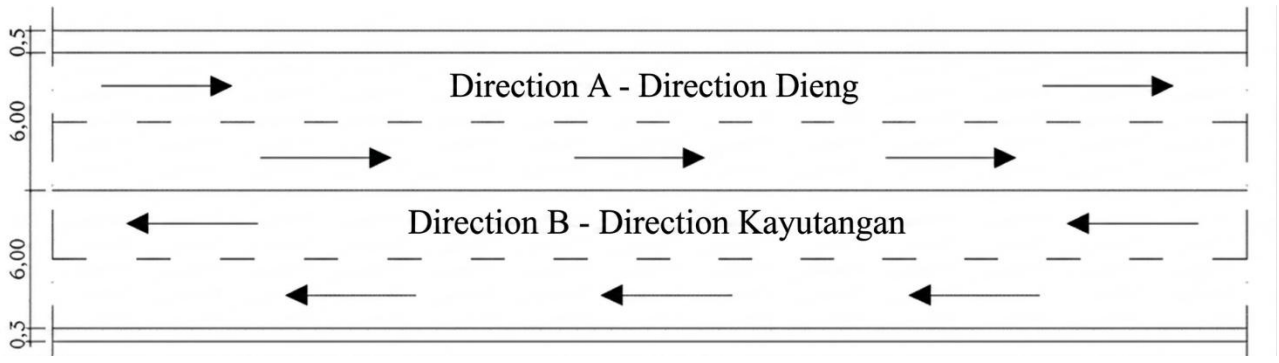

Figure 1. Cross-Sectional View of the Study Location for Direction A and Direction B (4/2/Undivided Road Type)

Traffic Flow Volume. Traffic volume measurements were conducted over two days, namely on Friday as a weekday and Saturday as a weekend. Observations were focused on peak hours, specifically in the morning from 07:00 to 08:00, at midday from 11:00 to 13:00, and in the afternoon from 16:00 to 18:00 (Western Indonesia Time/WIB), with data recorded at 15 minute intervals and subsequently converted into vehicles/hour, yielding traffic volume observation results at 60-minute intervals. The vehicle volume calculation results in units of vehicles/hour were analyzed to determine the peak hour in passenger car units (PCU/hour) by multiplying with the vehicle equivalency factor, thereby obtaining an accurate peak hour value [6].

Table 4. Traffic Volume on Friday and Saturday

Day	Period	Hour	Total Flow (Q) PCU/hour	Day	Period	Hour	Total Flow (Q) PCU/hour
Friday	Morning	07:00 – 08:00	932.8	Saturday	Morning	07:00 – 08:00	863.55
		07:15 – 08:15	989.45			07:15 – 08:15	925.7
		07:30 – 08:30	1003.8			07:30 – 08:30	952.3
		07:45 – 08:45	1024.85			07:45 – 08:45	982.85
		08:00 – 09:00	994.3			08:00 – 09:00	970.3
	Midday	11:00 – 12:00	1381.55		Midday	11:00 – 12:00	1450.55
		11:15 – 12:15	1414.6			11:15 – 12:15	1447.1
		11:30 – 12:30	1434.5			11:30 – 12:30	1210.75
		11:45 – 12:45	1390.7			11:45 – 12:45	1465.95
		12:00 – 13:00	1398.3			12:00 – 13:00	1465.4
	Afternoon	16:00 – 17:00	1470.85		Afternoon	16:00 – 17:00	1496.35
		16:15 – 17:15	1518.9			16:15 – 17:15	1582.45
		16:30 – 17:30	1508.9			16:30 – 17:30	1567.4
		16:45 – 17:45	1404.2			16:45 – 17:45	1474.2
		17:00 – 18:00	1263.05			17:00 – 18:00	1352.55

Based on the data presented in Table 4, the average peak hour traffic flow volume (Q) on Jalan Kawi Atas exhibits a characteristic pattern in accordance with the Indonesian Road Capacity Manual (PKJI) 2023. On Friday as a weekday, the Q value was recorded at 1024.85 PCU/hour in the morning, 1434.5 PCU/hour at midday, and 1518.9 pcu/hour in the afternoon. Meanwhile, on Saturday as a weekend, Q reached 982.85 PCU/hour (morning), 1,465.95 PCU/hour (midday), and 1582.45 PCU/hour (afternoon).

Side Friction. Side friction data collection was conducted by recording various types of activities that potentially disrupt traffic flow, such as vehicles parked on the shoulder or carriageway, non-motorized vehicles, pedestrians crossing, and vehicles entering or exiting from the roadside. Observations were carried out over a 200-meter segment, covering 100 meters to the right and 100 meters to the left of the observation point.

Table 5. Side Friction on Friday and Saturday

Day	Hour	Total Side Friction	Friction Criteria	Day	Hour	Total Side Friction	Friction Criteria
Friday	07:00 – 08:00	86	Very Low	Saturday	07:00 – 08:00	121	Very Low
	07:15 – 08:15	82	Very Low		07:15 – 08:15	113	Very Low
	07:30 – 08:30	81	Very Low		07:30 – 08:30	112	Very Low
	07:45 – 08:45	82	Very Low		07:45 – 08:45	115	Very Low
	08:00 – 09:00	81	Very Low		08:00 – 09:00	105	Very Low
	11:00 – 12:00	72	Very Low		11:00 – 12:00	93	Very Low
	11:15 – 12:15	67	Very Low		11:15 – 12:15	91	Very Low
	11:30 – 12:30	83	Very Low		11:30 – 12:30	85	Very Low
	11:45 – 12:45	71	Very Low		11:45 – 12:45	87	Very Low
	12:00 – 13:00	79	Very Low		12:00 – 13:00	98	Very Low
	16:00 – 17:00	113	Very Low		16:00 – 17:00	103	Very Low
	16:15 – 17:15	116	Very Low		16:15 – 17:15	114	Very Low
	16:30 – 17:30	108	Very Low		16:30 – 17:30	117	Very Low
	16:45 – 17:45	103	Very Low		16:45 – 17:45	116	Very Low
	17:00 – 18:00	77	Very Low		17:00 – 18:00	104	Very Low

Based on the survey results conducted on Friday and Saturday on Jalan Kawi Atas, Malang City, the side friction falls within the very low (VL) category.

Road Segment Capacity. Based on field observations conducted on Jalan Kawi Atas, Malang City, the road type was identified as 4/2 UD (four-lane, two-direction, undivided). Furthermore, measurement results indicate that the road geometric conditions are consistent with this road type. Malang City, with a total population of 0.87 million inhabitants, is classified as a medium-sized city. These data were subsequently used as the basis for calculating road segment capacity in accordance with the Indonesian Road Capacity Manual (PKJI) 2023, taking into account the road type factor, geometric conditions, and city size, all of which influence the capacity and performance values of the road.

Table 6. Road Capacity Calculation

C	C_O	FC_{LJ}	FC_{PA}	FC_{HS}

	3752	0.87	0.94	0.94
= 2538.17 PCU/hour				

Degree of Saturation. The degree of saturation represents the ratio between the traffic volume passing through a road segment and its capacity (Ministry of Public Works, 2023). Based on the results of the traffic flow analysis and road capacity calculations previously conducted, the degree of saturation values was obtained as follows.

Table 7. Degree of Saturation Calculation

Day	Q	C	DS
Friday	1518.2	2538.17	0.598
Saturday	1582.45	2538.17	0.623

Level of Service. The Level of Service (LOS) is a qualitative indicator used to assess traffic operational conditions on a road segment. It describes the quality of traffic flow based on the level of comfort, speed, and impedance experienced by road users. The LOS value is determined based on the degree of saturation (DS) and is classified into several categories, ranging from very smooth to highly congested conditions. The following presents the level of service results based on the collected data.

Table 8. Current Year Level of Service

Day	DS	Level of Service
Friday	0.598	C
Saturday	0.623	C

Based on the analysis conducted on Friday and Saturday in 2026, the Level of Service of Jalan Kawi Atas, Malang City falls within category C, indicating that traffic flow conditions remain stable but are beginning to be affected by impedance, resulting in limited vehicle speeds.
The Level of Service (LOS) for the next five years needs to be projected in order to assess changes in road performance resulting from future traffic volume growth. To predict future traffic conditions, traffic growth data are required as the basis for calculation. These data are used to estimate the projected increase in vehicle volume. The following presents the traffic growth data used as the basis for calculating the Level of Service over the next five years.

Table 9. Vehicle Volume Growth Factor for Malang City (BPS East Java, 2025)

Year	Number of Vehicles	Growth Factor (%)
2018	596,432	—
2019	602,973	0.01
2020	470,346	-0.22
2021	804,256	0.71

2022	977,243	0.22
2023	1,621,902	0.66
2024	1,667,756	0.03
Growth Factor		0.23

Based on the projected vehicle volume growth from current conditions, the following presents the predicted Level of Service for the next five years, derived using the following equations:

$$F = P \times (1 + i)^n \quad (3)$$

$$D_J = \frac{q}{C} \quad (4)$$

Table 10. Predicted Level of Service for the Next 5 Years Based on Degree of Saturation

Year	Total Traffic Volume (F)	Degree of Saturation (DS)	Level of Service Category
2027	1953	0.77	C
2028	2410	0.95	E
2029	2974	1.17	F
2030	3669	1.45	F
2031	4528	1.78	F

Based on the projected Level of Service over the next five years, the performance of Jalan Kawi Atas, Malang City is anticipated to deteriorate progressively from category C in 2027 to category F from 2029 through 2031. This indicates that traffic conditions are projected to become increasingly congested and approach saturation, necessitating appropriate mitigation measures to maintain optimal road performance in the future.

Alternative Solutions for Road Segment Performance. Based on the results of traffic volume surveys, side friction observations, and capacity calculations in accordance with the Indonesian Road Capacity Manual (PKJI 2023), the existing conditions (2026) indicate that the Level of Service of Jalan Kawi Atas falls within class C, with a degree of saturation ranging from 0.55 to 0.62. This suggests that traffic flow remains stable but is beginning to be affected by increasing vehicle volume and side friction, despite the side friction category still being classified as "Very Low (VL)." The five-year performance projection reveals a gradual declining trend, from LOS D in 2027 to LOS E in 2028, and subsequently LOS F from 2029 to 2031, indicating that road capacity will no longer be able to accommodate traffic volume growth, resulting in saturated and unstable road segment performance. This is consistent with road performance theory as outlined in PKJI 2023, wherein the degree of saturation (DS = q/C) serves as the primary indicator for determining the level of service, and road capacity is influenced by geometric factors (4/2 UD type, 12-meter width, medium-sized city) and the side friction adjustment factor FC_{HS}. Consequently, the combination of increasing vehicle volume, undivided road conditions, and inadequately managed roadside activities has led to a significant projected deterioration in road performance.

Based on the identified performance conditions, several technical and policy alternative solutions can be proposed to enhance capacity and maintain the Level of Service of Jalan Kawi Atas within the LOS B–C range. First, road capacity improvement should be undertaken through lane reconfiguration and the provision of additional movement space at critical points, for instance by reorganizing entry and exit access to commercial areas and adjusting lane configurations for greater efficiency. Second, side friction management should be strengthened through the regulation of on-street parking, restriction of roadside stopping during peak hours, and the reorganization of access nodes to commercial areas to prevent disruption to the main traffic flow. Third, traffic management aspects

can be enhanced through the improvement of road signs and markings, speed zone designation, reinforced enforcement of parking regulations and traffic violations, and the implementation of traffic engineering measures such as peak hour distribution and public transport pattern adjustments. By implementing these alternative solutions, it is anticipated that the degree of saturation can be reduced to an acceptable range, ensuring that the performance of Jalan Kawi Atas remains in conformity with the urban road service quality standards stipulated in PKJI 2023, while being capable of accommodating the high volume of educational, commercial, and public facility activities along the corridor.

Conclusion And Recommendations

Conclusion. Based on the capacity and level of service analysis in accordance with the Indonesian Road Capacity Manual (PKJI) 2023, the existing conditions (2026) of Jalan Kawi Atas indicate a Level of Service of C with a degree of saturation ranging from 0.55 to 0.62, suggesting that traffic flow remains operational but is beginning to be affected by increasing vehicle volume and roadside activities. Although the side friction category remains classified as very low, the combination of traffic volume growth, the 4/2 UD road type, and limited geometric capacity improvement has resulted in a notable decline in road performance. The five-year performance projection reveals a gradual deterioration from LOS D in 2027, to LOS E in 2028, and subsequently LOS F from 2029 to 2031, indicating that the road segment is at risk of operating under saturated and unstable conditions if capacity enhancements and improved traffic management are not implemented.

Recommendations. Based on the results of the analysis and discussion conducted, several recommendations can be proposed as initial measures to improve the performance of Jalan Kawi Atas, Malang City in both the short and long term, as follows:

1. Road Capacity Improvement
   Lane configuration restructuring and adjustment of entry and exit access to commercial areas, educational facilities, and public amenities should be carried out, so that the main traffic flow is not disrupted and road capacity can be utilized more efficiently.
2. Side Friction Management
   Regulation and restriction of on-street parking, reduction of vehicles stopping along the roadside during peak hours, and reorganization of access nodes to commercial areas should be enforced, in order to minimize impedance to the main traffic flow and prevent disruption to traffic movement.
3. Strengthening Traffic Management and Enforcement
   Improvements to traffic management are recommended through the enforcement and adjustment of road signs and markings, speed zone adjustments, and strengthened enforcement against traffic violations and illegal parking, with the aim of enhancing road user comfort and safety.

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